The Nearly Classical Behavior of a Pure Fluid on the Phase Boundary Very Near the Critical Point Under Gravity Influence

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As first reported at the 11th Symposium on Thermopysical Properties, we developed a new multi-cell apparatus, specially designed for extremely accurate $p\rho T$ measurements in the critical region of pure fluids. In a first step we carried out comprehensive measurements in the critical region of pure SF_6 and found for all "thermal" critical exponents nearly "classical" values, namely $\beta = 0.49$, $\gamma = 0.98$, and $\delta = 3.0$ in the limiting approach to the critical point. Only at a distance from the critical point (in the case of β and γ for $\tau \approx 2.82 \cdot 10^{-4}$), did we observe a transition to values which nearly meet the predictions of the renormalization group theory. Based on the corrections for the density stratifications, this transition point could be identified as the limit of the gravity influence on the thermal behavior of SF_6. In a second step we have chosen CO_2 for our measurements, a fluid with a considerably smaller critical density, and have found that on the critical isochore the transition point of the critical exponent γ has moved closer to the critical point ($\tau \approx 1.81 \cdot 10^{-4}$) corresponding to the different critical densities of SF_6 and CO_2. In subsequent measurements, we have therefore focussed on the question, whether the same different loci of the transition points for SF_6 and CO_2 can also be found for the critical exponent β.

Besides the new measurements on the phase boundary of CO_2, we have made a careful reevaluation of our previous measurements of the saturation densities in the critical region of SF_6. By means of an improved model for the correction of the saturation densities due to density stratifications, we have now found the same value of the critical temperature as determined from pressure measurements on the critical isochore. For both fluids, and at a certain distance from the critical point similar to the results obtained for the isothermal compressibility, we have observed the transition from the behavior according to the renormalization group theory ($\beta_f \approx 0.35$) to the near classical value of $\beta \approx 0.45$. For both the paths on the critical isochore and on the phase boundary, in the immediate vicinity of the critical point, a universal nearly classical behavior can therefore be assumed; the range of this explicit gravity influence, however, depends on the type of fluid. Furthermore, our measurements with the multi-cell apparatus have been supplemented and are strongly confirmed by new measurements of the saturation densities made with our two-sinker densimeter. Therefore, with respect to the law of the rectilinear diameter we can now prove that there is indeed no need for a value of the critical exponent α which differs from zero.